American Trucking Associations Technical Advisory Group Presentation

24 January 2012

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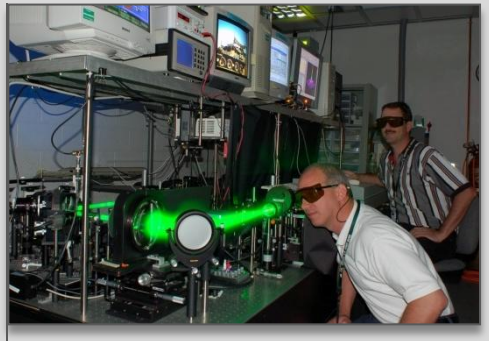
Presentation Agenda

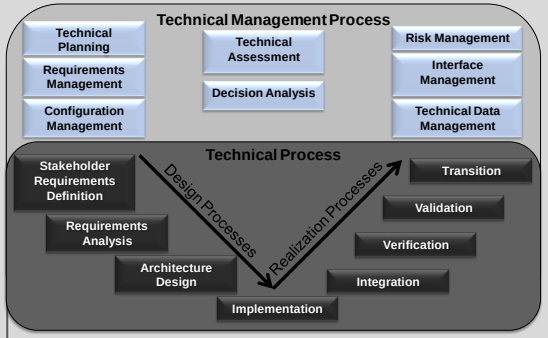
- TARDEC/NAC Overview
- DOD/DA/DOE AVPTA
- 21CTP

Capabilities



Research

Development



Engineering

Integration

Production Support

Field Support

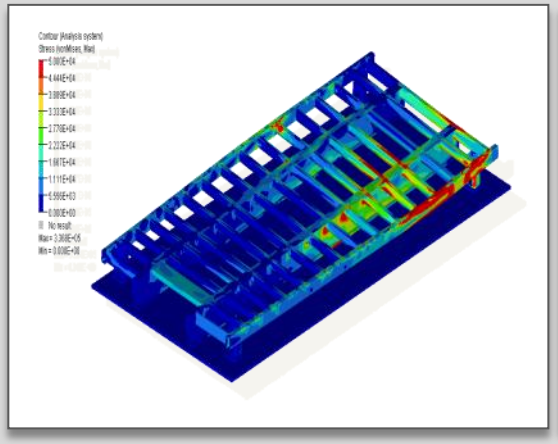
Exploiting Strategic Relationships is Key to Innovation

- Connected to World-Class Automotive Engineering Universities at our Doorstep
- Defense Industry Ground Systems Hub
- Direct Linkage to World-Class Automotive Research and Development Centers
- Strategic Engagement with 1st, 2nd & 3rd Tier Automotive Supplier Network

Facilities

Laboratory Capabilities

- Ground Systems Power and Energy Laboratory (GSPEL)
- Advanced Concepts Laboratory
- Advanced Collaborative Environments (ACE)
- Laser Protection Laboratory
- Armor Nondestructive Testing Laboratory
- Robotics Systems Integration Laboratory
- Ground Vehicle Systems Integration Laboratory
- GVR Robotic Laboratories
- Electronics Integration
- Physical Prototyping
- Design & Digital Mock-up
- Metallurgy Test Laboratory
- Survivable Structures Laboratory
- Ground Vehicle Power & Mobility Elastomer Improvement Laboratory
- Ground Vehicle Power & Mobility Propulsion Laboratory
- Physical Simulation Laboratory
- Analytical Simulation Laboratory
- TARDEC Simulation Labs
- Survivability Armor Ballistic Laboratory (SABL)
- Fuels & Lubricants Laboratories
- Water Purification, oil, fuels and lubricants Laboratory
- Fresh Water Test Facility
- NFESC Seawater Test Facility
- Dynamic Structural Load Simulation Lab



TARDEC's Warren, MI operations have a resource value of over $1.1B and occupy 12 facilities on the Detroit Garrison totaling over 936,000 square feet of laboratory space

Focus

Key Technical Thrust Areas

- Occupant Centric Vehicle Protection
- Vehicle Networks, Architectures, Computers
- Requirements, Analysis & Prototype, and Autonomy in Robotics
- Mobility & Energy Efficiency
- Countermine, Petroleum & Water Supply, Bridging, Handling Equipment

Army Technical Challenge
More Mobile, Fuel Efficient, Safer Vehicles

Mobility & Energy Efficiency

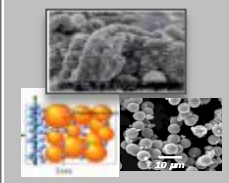
Vehicle Dynamics

Newton-Euler Equations of Motion

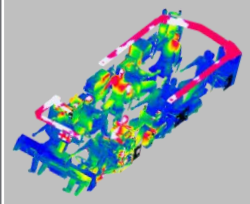
$$\left.\begin{aligned}\mathbf{M}\ddot{\mathbf{q}}+\mathbf{C}_{\mathbf{q}}^{T}\boldsymbol{\lambda}=\mathbf{Q}\\ \mathbf{C}(\mathbf{q},t)=\mathbf{0}\end{aligned}\right\}$$

Solve for vehicle mobility and component loads

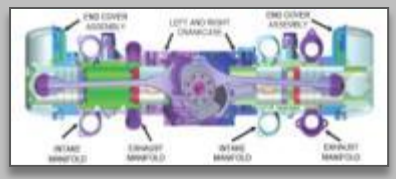
$$\begin{bmatrix}\mathbf{M} & \mathbf{C}_{\mathbf{q}}^{T}\\ \mathbf{C}_{\mathbf{q}} & \mathbf{0}\end{bmatrix}\begin{bmatrix}\ddot{\mathbf{q}}\\ \boldsymbol{\lambda}\end{bmatrix}=\begin{bmatrix}\mathbf{Q}_{e}+\mathbf{Q}_{v}\\ \mathbf{Q}_{d}\end{bmatrix}$$



Hi-Energy, Hi-Density Energy Storage



Comprehensive Thermal Management of Propulsion & Cabin



High Power Density, Low Heat Rejection & Fuel Efficient Engines

Multi-Physics Optimization

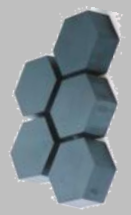
Occupant Centric Survivability

Active Protection Systems

Holistic Occupant Centric Protection

$$\frac{d}{dt}\int_{Vt} f(x,t)dV=\int_{Vc=Vt}\frac{\partial f(x,t)}{\partial t}dV+\int_{Sc=St} f(x,t)\bullet ndS$$

Affordable, Multi-hit Ceramic Armor



Fire and Toxic Fume Resistant Materials

Army Power and Energy

Basing

Installation | Contingency

Soldier

Vehicles

Tactical | Non Tactical

Air

Land

OPERATIONAL ENERGY

NET ZERO STRATEGY

"Grand Challenges"

- Give Soldiers and leaders capability to manage energy status, resources and performance
- Significantly reduce energy footprint
- Provide flexibility and resiliency by developing alternatives and adaptable capabilities

Power and Energy Strategy White Paper, Army Capabilities Integration Center/Research, Development and Engineering Command /Deputy Chief of Staff, G-4, US Army, 1 April 2010

National Automotive Center (NAC)

Chartered by the Secretary of the Army on 21 June 1993

Mission:

"The Center will serve as the Army focal point for the development of dual-use automotive technologies and their application to military ground vehicles. It will focus on facilitating joint efforts between industry, government and academia in basic research, collaboration, technology, industrial base development and professional development."

"Leveraging Opportunities to Fill Technology Gaps."

National Automotive Center (NAC)

Command Chain

Army Materiel Command (AMC) – Huntsville, AL

Research, Development & Engineering Command (RDECOM) – Aberdeen, MD

Tank-Automotive Research, Development & Engineering Center (TARDEC) – Warren, MI

National Automotive Center (NAC) – Warren, MI

Core Competencies (Refocused Dec 2011)

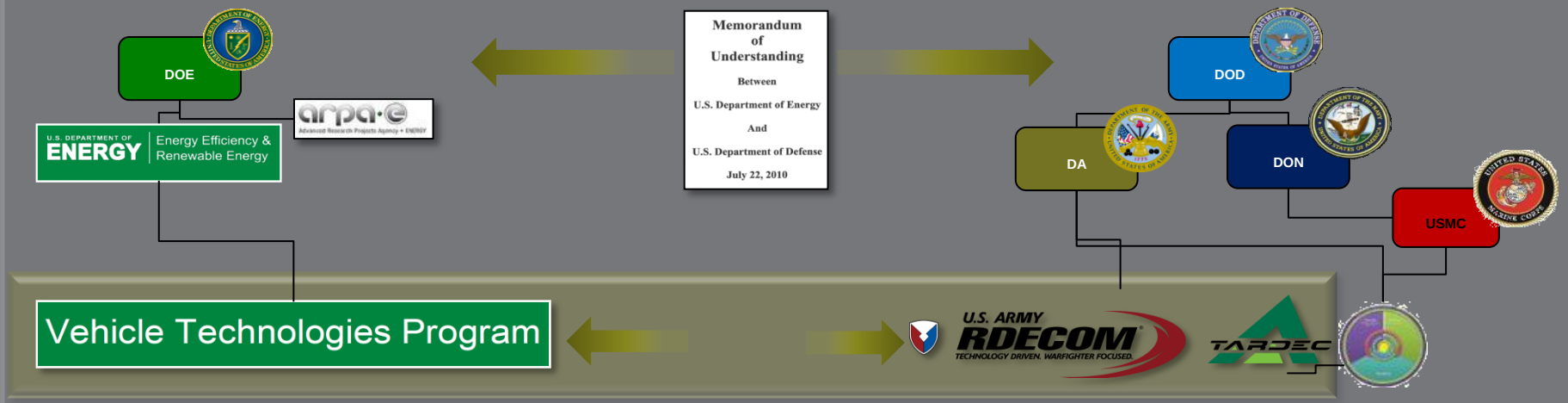
- Industry Connections:
  - Associations (AUSA, NDIA, ATA, EMA, …)
  - Automotive (OEMs/Suppliers, USCAR/USDRIVE)
  - Construction, Off-Road & Military Equipment (OEMs/Suppliers)
  - Engine, Truck & Advanced Propulsion Systems Manufacturers (HTUF)
  - Fleet/Infrastructure Electrification (EDTA, EPRI, …)
- Commercial Technology Evaluations
- Government Collaboration
  - DOE/National Labs
  - DOT/NHTSA
  - EPA
  - NIST
- Technology Incubation
  - Cooperative Research & Development Agreements (CRADAs)
  - Small Business Innovative Research Grants (SBIRs)
  - Small Business Technology Transfer Programs (STTRs)
- Education Partnerships
  - Science, Technology, Education & Mathematics (STEM)

Significant Activities

- MOU between DOD and DOE signed - 22 July, 2010
- Coordination with ASA(ALT) to have alliance under MOU– Spring 2011
- Scoping of alliance to focus on vehicle P&E - Spring 2011
- Charter Signed -18 July, 2011
- Workshop to find dual use tech areas -18-19 July, 2011
- Post workshop data analysis and completion - 20 July – 5 Aug 2011
- Monthly meetings between Davis and Bochenek - May – Oct. 2011
- Development of DA-DOE coordination plans -11 Aug –13 Sept 2011
- Update and finalization of Workshop report - 3 Oct, 2011
- Agreement of quick win joint projects - 3 Oct, 2011
- Formulation of operating construct - 3 Oct, 2011
- Agreement to fund joint projects - Early Dec, 2011

DOD/DA/DOE Advanced Vehicle Power Technology Alliance (AVPTA)

AVPTA Organizational Construct and Operational Tempo



	AVPTA Quarterly Meetings											
Principals	**Q1 December** Review current portfolio of each organization			**Q2 March** Identify gaps in individual and joint portfolios in light of emerging strategic and operational drivers			**Q3 June** Joint planning to support the respective agency's budgeting process			**Q4 September** Joint technical meeting		
Technical Groups	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**

37 Coordination Opportunities

- Cross-pollinate technical experts in working groups
- DOD/DA experts participate in technical and program reviews
- Key reviews of investments and programs
- Strengthening existing venues for technical exchange
  - Interagency Advanced Power Group
  - DOE Annual Merit Review
  - Agency specific technical meetings
- Establishing a new Lightweight Materials Working Group
  - This a specific gap identified as a result of the AVPTA Technical Work Group
- Develop new power technology standards
  - Society of Automotive Engineers, Department of Transportation, Military Standards
- Inclusion of agencies in key technical symposia
  - GVSETS, DEER, and HTUF

21 Project Integration Opportunities

- Partnering to leverage existing projects that do not require additional funding
- Plan and review a project specific joint portfolio through quarterly principals meeting
  - Multiple high priority projects identified in every technical area
  - Conducted with the intent to identify complementary joint endeavors
- Build on ongoing forums
  - US DRIVE Tech Team meetings
  - Advanced Engine Combustion MOU
- Fast-tracked, joint planning for a project in the Thermal Management
  - Thermoelectrics and Enabling Engine project will be concluded in October

Achieving Common Goals In Joint Technology Areas

Advanced Combustion Engines and Transmissions	Lightweight Structures and Materials	Energy Recovery and Thermal Management	Alternative Fuels and Lubricants	Hybrid Power Systems	Analytical Tools
• High density, energy efficient powertrain • Extreme gains in engine efficiency	• Reduce weight to improve performance • Cost reduction for consumer market ❖ Lightweight vehicle structures	• Cost Improved efficiency, manage heat generation • Efficiency gains through waste heat recovery ❖ Thermoelectrics and Enabling Engine	• Standardization & security • Efficiency gains through advanced oil formulations ❖ Test method development for fuel bulk modulus	• Efficiency improvements ❖ Computer Aided Engineering for Batteries (CAEBAT)	• Assessment/ Design Trades

Quick Win Joint Endeavors (1 of 2)

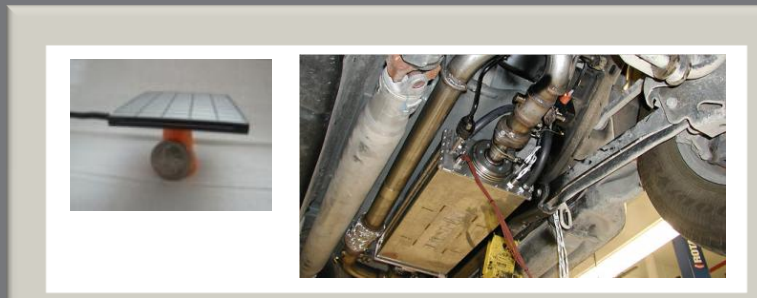
Lightweight Vehicle Structures

Utilize automotive technology investments in vehicle structure light weighting

Motivation
- Demonstrate best practices in multi-material design for
- structures to reduce ground vehicle weight

End result
- Demonstrate a weight savings of up to 1,500 lbs on a LAV

Thermoelectrics and Enabling Engine



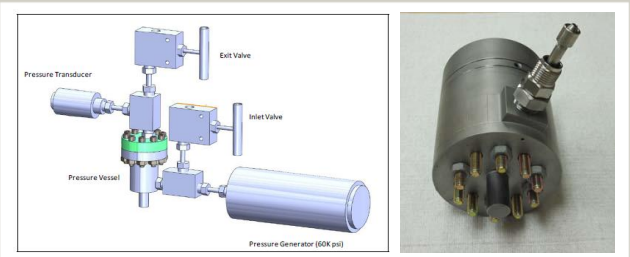
Improve platform efficiency by recovering thermal energy from the engine exhaust for military and passenger/commercial vehicles

Motivation
- Accelerate development of cost competitive, second generation thermoelectric devices for vehicle applications
- Projected overall vehicle efficiency gains of up to 5%

End result
- Three competing ~1kW Thermoelectric Generators (TEGs)
- Higher fidelity in-house TEG sub-system laboratory

Quick Win Joint Endeavors (2 of 2)

Test Method Development for Fuel Bulk Modulus



Develop an improved test method to determine the bulk modulus of liquid transportation fuels

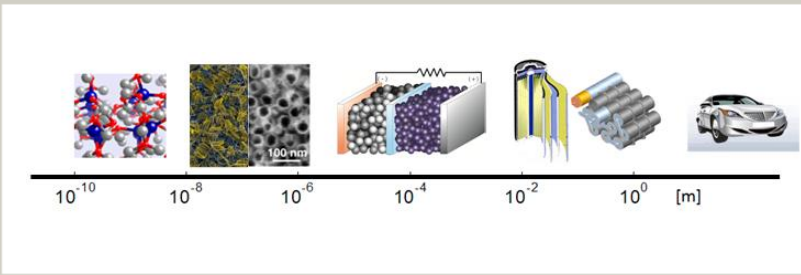
Motivation

- The bulk modulus of compressibility of a fuel can have a significant impact on fuel behavior and engine performance
- An improved test method will assist researchers and developers in advancing the implementation of alternative fuels into the transportation sector

End result

- Publication of test method as a Federal Standard in FED-STD-791, Lubricants, Liquid Fuels, and Related Products
- Data for key fuel property currently minimally reported

Computer Aided Engineering for Batteries (CAEBAT)



Develop battery design suite that that encompasses models ranging from electrochemical & cell level all the way to pack & systems

Motivation

- Reduce energy storage system development time and cost while improving safety and performance
- Leverage new tools to predict and improve abuse and ballistic tolerance of cells and energy storage systems

End result

- Reduction in overall development cost with a significant improvement in safety, performance and life for dual use advanced energy storage systems.

DOD/DA/DOE Advanced Vehicle Power Technology Alliance (AVPTA)

Next Steps

Strengthen the DOE-DA partnership and continue to lead and establish a routine, repeatable process to **bear long-term results.**

Near term

- Conduct detailed reviews of the remaining potential joint endeavors
  - Target completion December 2011
- Ensure executive leadership remains engaged
  - Target quarterly meetings
- Ensure PI-to-PI technical thrust leads are productive
  - Target monthly meeting
  - Monthly reporting

Long term

- Develop and execute an annual program planning, review, and portfolio process.

Vision

The vision of the 21st Century Truck Partnership is that the nation's trucks and buses will safely and cost-effectively move larger volumes of freight and greater numbers of passengers while emitting little or no pollution and dramatically reduce the dependency on foreign oil. The Partnership addresses the following national imperatives:

Transportation in America supports the growth of the nation's economy both nationally and globally.

The nation's transportation system supports the country's goal of energy security.

Transportation in the country is clean, safe, secure, and sustainable

.

America's military has an agile, well-equipped, efficient force capable of rapid deployment and sustainment anywhere in the world.

The nation's transportation system is compatible with a dedicated concern for the environment.

Partnership Activities

Develop and implement an integrated vehicle systems research and development (R&D) approach that **validates and deploys advanced technology necessary for both commercial and military trucks** and buses to meet the aforementioned national imperatives.

Promote research for engine, combustion, exhaust aftertreatment, fuels, and advanced materials to achieve both **significantly higher efficiency** and lower emissions.

Promote research focused on **advanced heavy-duty hybrid propulsion systems** that will reduce energy consumption and pollutant emissions

.

Promote research to **reduce parasitic losses** to achieve significantly reduced energy consumption.

Promote the development of technologies to improve **truck safety**, resulting in the reduction of fatalities and injuries in truck-involved crashes.

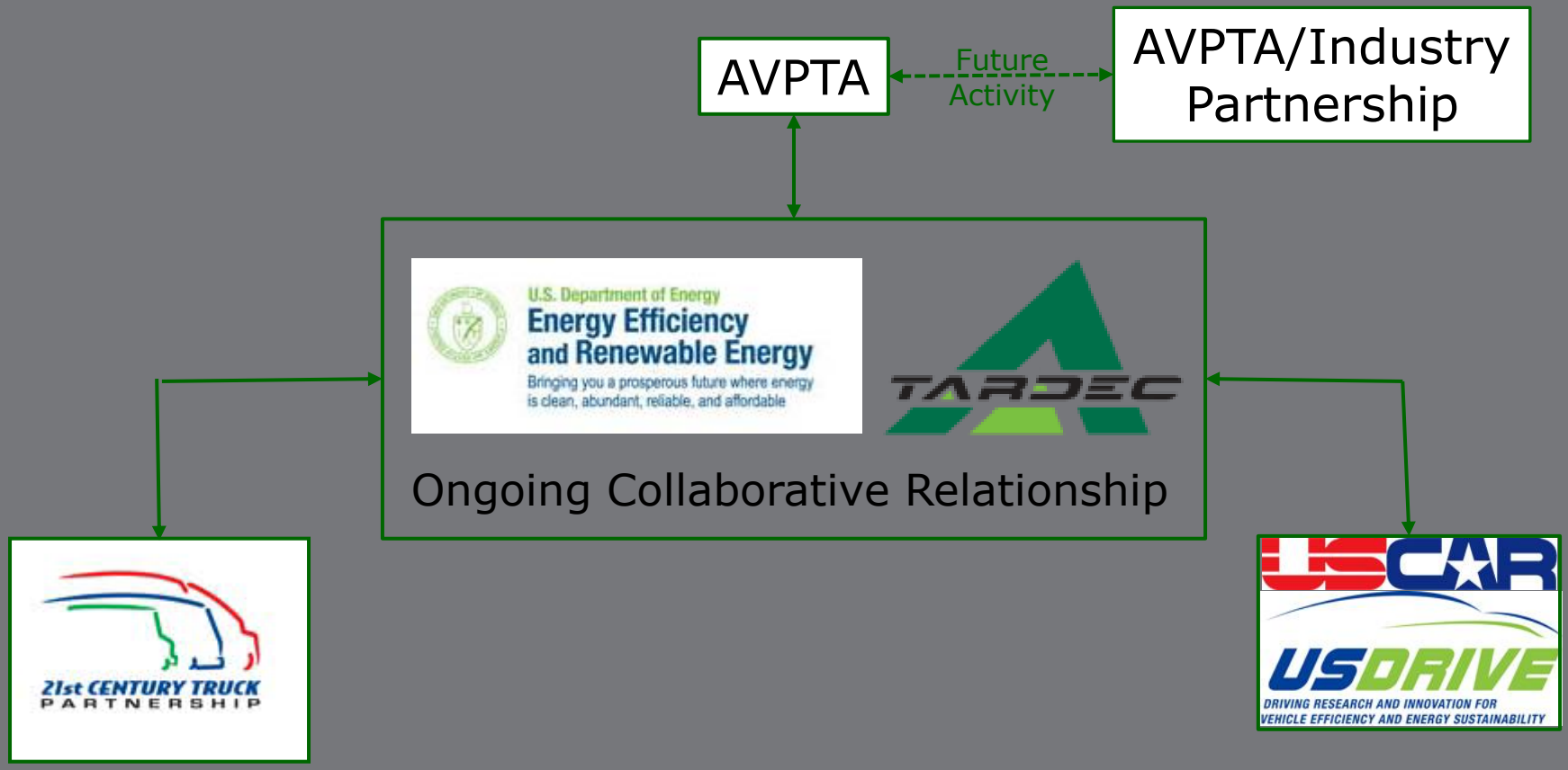
Partnership Activities (Cont.)

Promote the development and deployment of technologies that **substantially reduce energy consumption** and exhaust emissions during idling.

Promote the validation, demonstration, and deployment of advanced truck and bus technologies, and grow their reliability sufficient for adoption in the commercial marketplace.

21st Century Truck Program (21CTP)

NAC Perspective



TARDEC's Ground Vehicle Gateway

https://tardec.groundvehiclegateway.com